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INVESTIGATIONS ON SIGNIFICANCE OF CNT'S ORIENTATION ON CNT BASED SILK NANOCOMPOSITES THROUGH FEA METHOD

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ABSTRACT

The present project work in the nanotechnology field has created growing possibilities for the advanced field of materials. Among these advanced materials with advanced mechanical potential properties are Nanoreinforced Nanocomposites. The most general materials utilized as a matrix in the Nanocomposites are Polymers (e.g. poly-epoxide etc), Ceramics (e.g. porcelain, etc), and Metals (e.g. aluminum, iron, steel). An analysis is considered for Aluminum AA8090 as a matrix and different types of reinforcement by using (Carbon Nanotubes, Carbon Nanoparticles, and Carbon Nanolayers). The approaching modeling for these Nanocomposites is known as Representative Volume Element (RVE) through the FEA software called ANSYS. Various cases will be considered for studying mechanical properties such as deformation, stress, and strain of Nanocomposites with aligned oriented reinforcement and then make a comparison between the results to see which type of reinforcement will give the best performance. In this simulation, the tension and compression loads of 100nN is to be applied for analysis purpose and the results will be recorded.

KEYWORDS: CNT, Silk, Nanocomposites, FEA & ANSYS

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Original Article

1. INTRODUCTION

In this field, Nanotechnology, Nanocomposites have been recognized as one of the huge potential areas. A nanocomposite is a nanocrystalline material in the range of 1nm to 100nm (10^{-9}m). They can be produced through embedding reinforcement (e.g., nanofibers) in a matrix, similar process to Traditional composites. This is mainly the popular bottom-up process, not like the conventional technique of producing products from the required raw materials. Conventional composite materials like carbon-fibers are already used with high strength reinforcements have become the added advantage for the advanced aerospace industry. The nanofibers especially nano-tubes used in aero industry because they are more than 60 times stronger and 6 times lighter when compared with steels. Fatigue strength is the most important property of aircraft components in the aircraft design. However, the aircraft components must be made by using stronger material because the fatigue strength decreases due to enduring cyclic loading. If the fatigue is reduced then, life period of aircraft will be improved. If the grain size of the material reduced, then this can increase the strength of the fatigue. Technically, we must know that the nanomaterials offer considerable reducing particle size comparing bulk materials. In this project work, for structural analysis nanocomposite matrix fiber symmetric boundary conditions are considered. Keeping thickness and matrix geometry is constant for cutout shape and effect of stress concentration, variable nanofiber length has been considered. The von mises stresses of CNT fibers i.e., for the distances 2.4nm, 4nm and 6nm will be obtained.

The deformation of the matrix between CNTs in the composite will be calculated.

2. LITERATURE REVIEW

Composite materials are naturally obtained blend two or more essential materials with considerably dissimilar physical and chemical properties. They continue different and protected at the macroscopic and/or microscopic level of their finished structures. The ingredient material basically of 2 types viz; (i) matrix & (ii) reinforcement: Matrix supports this reinforcement. **M. Bourchak**et al [1]-The technical paper discussed the entrenched reinforcement (e.g., nanofibers / nano-tubes) in a matrix as the polymer in a similar manner to the conventional composite material. The nano-composite materials field has the attention; imagination. **Ye Hou[2-4] -**these contribution SWNTs and more defective MWNTs, the thin FWNTs are believed to have amazing mechanical properties. However, the enhancements of mechanical properties in FWNTs-polymer composites are stay behind indefinable. **L. Roy Xu [5-13]** Tensile and shear strength tests of metal/metal and polymer/polymer joints featuring a new functionalized nanofiber/epoxy composite adhesive were conducted. Strength increase is not as high as we expected (only up to 30%) even though we used GCNF-ODA reactive linkers to develop the interface. The moderate strength increase is due to high interfacial stress developed in nanocomposites because of the high stiffness property mismatch, and inefficient interfacial shear stress transfer through the shear-lag mechanism.

3. METHODOLOGY

The highly stiff nano CNT fibers with the matrix is predictable that the nanocomposite must be supposed to have superior strength compared to resin, or else this may not a great deal of enhancement. The main theme of this FEM method is to the investigation of the stresses in both matrix and reinforcement. The FEA modeling was carried out through the software ANSYS-10 to obtain a variety of stresses in the matrix and in the nanofibre interfaces. The projected FEA study process is based on the CNT of a nanocomposite material. I have taken as polymers in nano CNT composite material which is epoxy material then the carbon nanotube reinforcing in the composite material then we have applied 10MPa which is in y-direction. Under tensile stresses, investigations were carried out by loading different various forms of CNT Composites to 10MPa. The stiffness of CNT is 10^6MPa, matrix material (silk) E= 600GPa. The nanocomposite matrix length taken as 10 nm and width is 10 nm and the thickness is 5 nm radiuses are 1.4nm. And the thickness of CNT is 0.2nm. I have taken a comparison of various distances between two CNTs.

- The distance between two CNTs in the composite plate is 2.4 nm.
- The distance between two CNTs in the composite plate is 4.0 nm.
- The distance between two CNTs in the composite plate is 6.0 nm.

We have taken different types of length in nanocomposite material. Applying the load which is in y-direction. The output result which is displacement, von mises stresses and maximum principal stresses results are taken into consideration. The structural analysis of nanocomposite matrix fiber symmetric boundary conditions. The nanocomposite plates have varying nanofiber length, but the thickness and matrix geometry are remained same, finally varying the carbon nanofiber lengths while an increase in the strength of nanocomposite material. Higher the fiber lengths of 40nm having high-quality potential in producing very good strength nanocomposite.

4. ANALYSIS USING THE ANSYS FEA SOFTWARE

The ANSYS is 'general purpose' software, that can be used for all types of F.E.A. Analyses that can perform in ANSYS are static, modal, harmonic, transient, spectrum, Eigen buckling and substructuring. Static analysis is done in this thesis and described in the next section as shown in Figure 1.

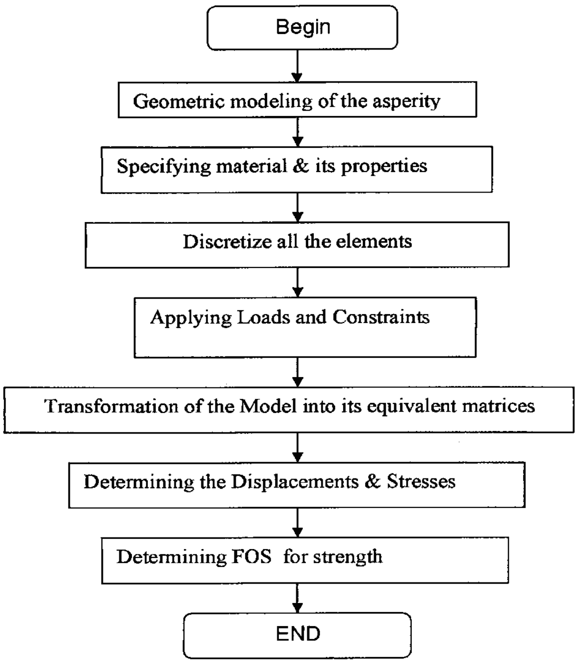

Figure 1: Contact Stress Analyses

5. SIGNIFICANCE OF CONTACT STRESS ANALYSIS

In spite of the significance of contact in the solid mechanics, contact effects are not taken into consideration in conventional engineering analysis. Because the great complication is concerning. Mechanical problems connecting contacts are intrinsically nonlinear. Normally the loading sources shows important in stiffness, results in structure and nonlinear. Nonlinear structural behavior used for the number of reasons. They can be reduced to 3 major categories:

- Geometric Nonlinearities (Large Strains)
- Nonlinearities in Material (Plasticity)
- Status Nonlinearities (Contact).

6. F.E. MODELING OF NANO-COMPOSITE MATERIAL

The highly stiff nano-fibers with the matrix will have higher strength than the resin. The main aim of F.E analysis is to give the impression of the stresses at both the matrix and mostly the reinforcement. This modeling is carried out through ANSYS software for finding out all types of stresses at the nanofibre boundary. As demonstrated in the behavior of RVE in the tensile stress is investigated by means of loading a variety of structures of the RVE to 10MPa. These outward appearances are characterized by nanofiber shape and length. While doing analysis, a value called 'constant' will be taken into consideration by ANSYS software for nanofiber contact as 5nm. Though, changing it has no significant effect on obtaining stress results. Maximum principal stresses, von mises stresses, normal stresses, etc., are analyzed with the

nano-fiber short interface in direction of x and along with nanofiber cross-section (e.g., nanofiber, stresses, etc) on the nanofiber as shown in Figure 2 and Figure 3.

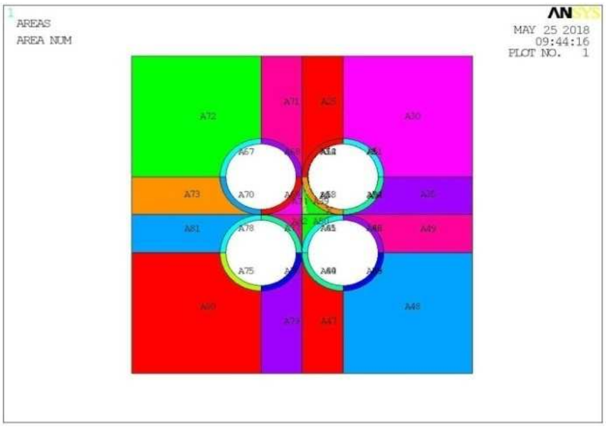

Figure 2: Different Cross-Shaped Nanofibers

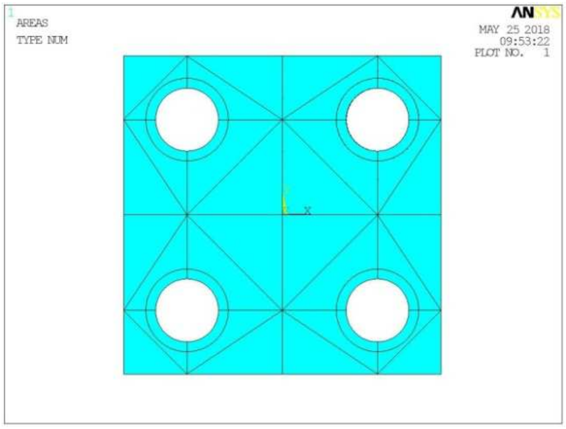

Figure 3: Different Cross-Shaped Nanofibers were Investigated

In the plane stress with thickness model, the nanofiber was considered as a single incorporated part. The plane stress with thickness FE model of composite material which is shaped to a great extent decreases the modeling and analysis comparing the time with the equivalent 3D model. The model has meshed with Quadrilateral 4-noded 2D solid elements. It is a 4-nodded element with 2-d.o.f each node with translations in both the x, y directions.

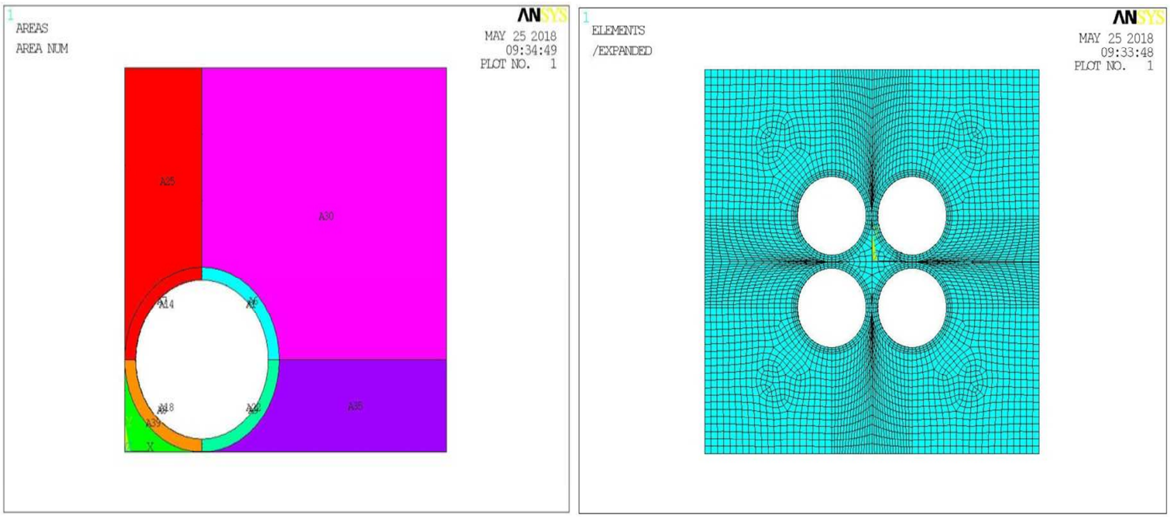

Figure 4: 2D Modeling of a Nanocomposite Material

The above figure shows that 2d modeling of a nanocomposite material in ANSYS. The matrix dimensions are height is 10nm, width is 10nm and thickness is 5 nm. The above figure shows that 2d finite element modeling of a nanocomposite material in ansys. Meshing has done by Quadrilateral 4-noded 2D solid element as shown in Figure 4.

7. RESULTS AND DISCUSSIONS

In this project, analysis is carried on a thin composite plate that is taken into account is Carbon Nano-tubes (CNTs) with silk as the matrix. The plate size is 10nm×10nm×5nm and the CNT radius is 1.4nm. In this work, CNTs are aligned in different distances in the same size composite plate at constant load of 10 MPa.

7.1 The Distance between two CNTs in the Composite Plate: 2.4 nm

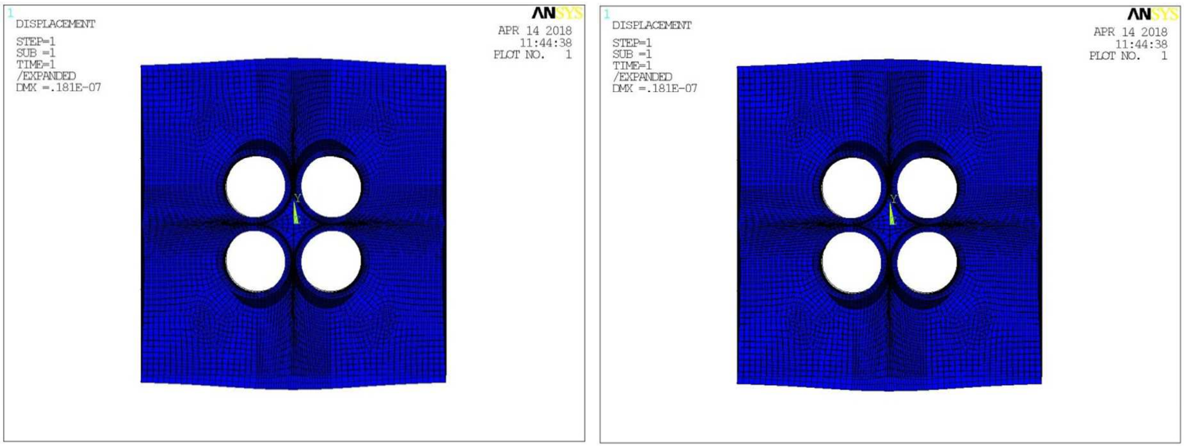

Figure 5: Deformation of the Composite

From the above contour, it is observed that maximum deformation is 1.81e-2 nm and the distance between CNTs id 2.4nm. From the above figure, we have experimentally known that the maximum deformation 1.81e-2nm accurse at top and bottom of the composite and minimum is 0 nm at the middle of the composite. Above figure shows that von mises stresses of the composite. From the above figure, we have experimentally known that the contours have maximum von mises stresses is 269.013 MPa and minimum is 0.649e-6 MPa. Maximum stress is naked at middle which is indicating red in color as well minimum is observed at boundaries of the composite which is blue in color as shown in Figure 5.

7.2 The Distance between two CNTs in the Composite Plate is 4.0 nm

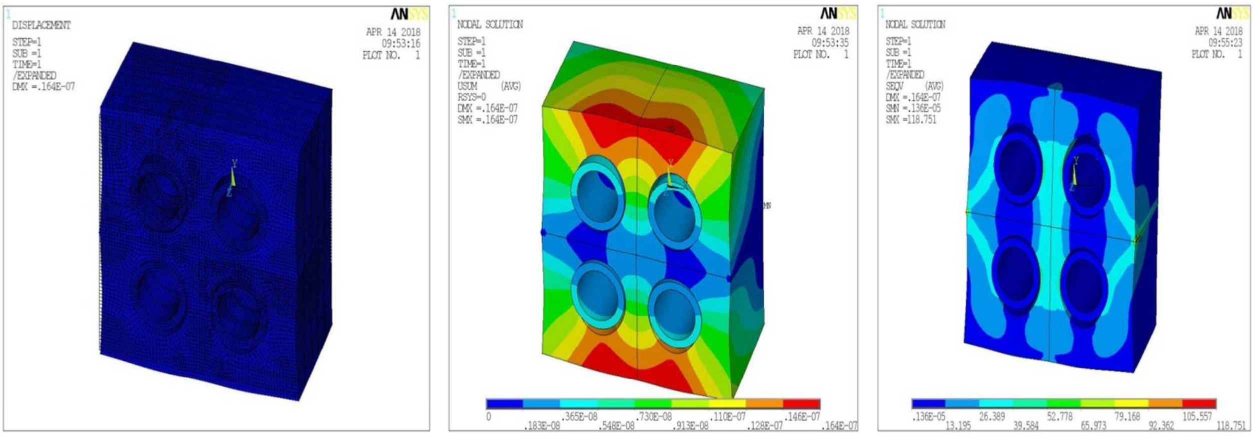

Figure 6: Deformation of the Composite

From the above contour, it is observed that maximum deformation is 1.64e-2 nm and the distance between CNTs id 4nm. From the above figure, we have experimentally known that maximum deformation 1.64e-2 nm accurse at top and bottom of the composite and minimum is 0 nm at the middle of the composite. Above figure shows that von mises stresses of the composite from the above figure, we have experimentally known that the contours maximum von mises stresses are 118.751 MPa and minimum are 0.136e-5 MPa. Maximum stress is naked at middle which is indicating red in color as well minimum is observed at boundaries of the composite which is blue in color as shown in Figure 6.

7.3 The Distance between two CNTs in the Composite Plate is 6 nm

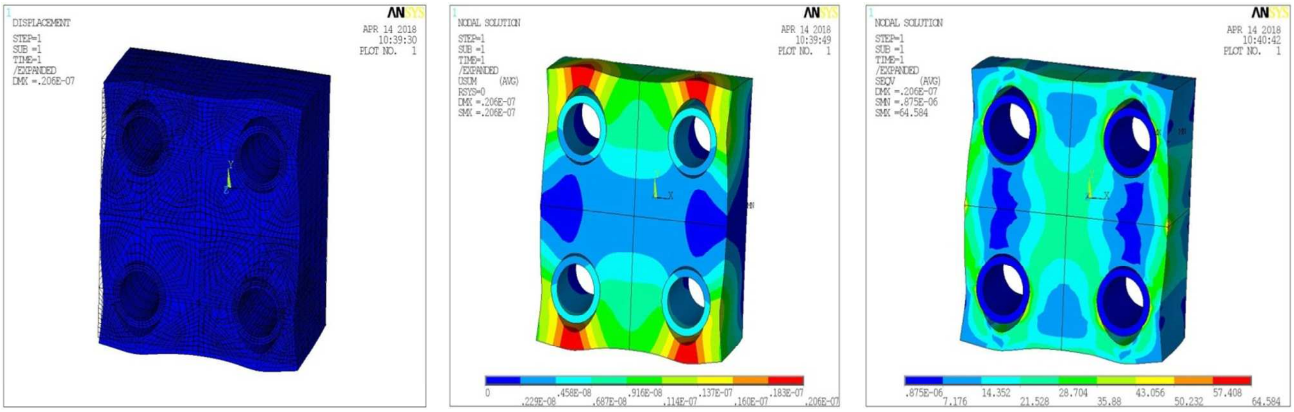

Figure 7: Deformation of the Composite

From the above contour, it is observed that maximum deformation is 2.06e-2 nm and the distance between CNTs id 6 nm. From the above figure, we have experimentally known that maximum deformation 2.06e-2 nm accurse at top and bottom of the composite and minimum is 0 nm at the middle of the composite. Above figure shows that von mises stresses of the composite. From the above contours, it is observed that maximum von mises stresses are 64.584 MPa and minimum is 0.875e-6MPa. Maximum stress is naked at the middle which is indicating red in color as well minimum is observed at boundaries of the composite which is blue in color as shown in Figure 7.

8. GRAPHICAL REPRESENTATION OF RESULTS

These graphs are extracted from inter-phase of the two CNTs, located in composite at a distance of 6 nm.

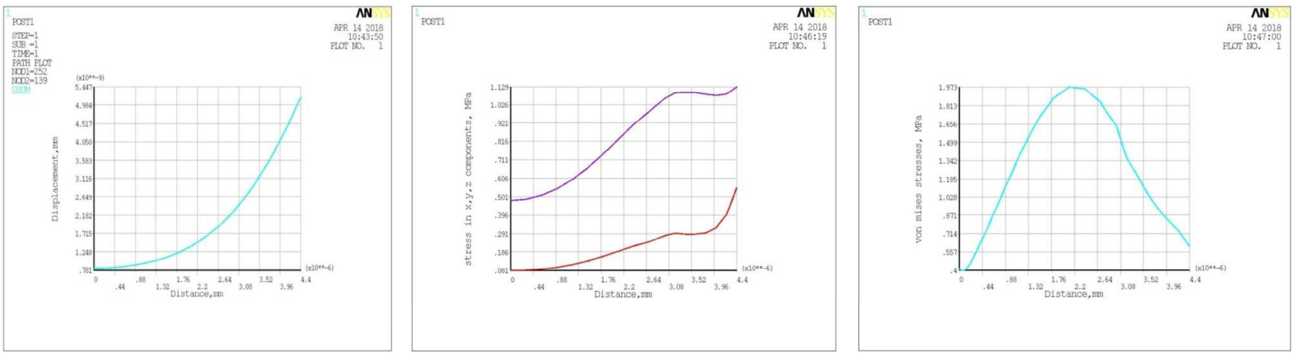

Figure 8: Deformation of the Composites

From the above figure, we have experimentally known that maximum deformation has occurred at inter-phase of the two CNTs is 5.447e-3 nm. Above figure shows that stress in x, y, z components. From the above figure, we have experimentally known that the maximum is in the x and y components that is 1.64MPa. And component z is having less stress value. From the above figure 7.19, it is observed that von mises stresses of the composite at inter-phase of CNTs are very less as compared to the yield point of the material.

9. CONCLUSIONS

In this project work, for structural analysis nanocomposite matrix fiber symmetric boundary conditions are considered. Keeping thickness and matrix geometry is constant for cutout shape and effect of stress concentration, variable

nanofiber length has been considered. The following conclusions were made from the present work. It is concluded that the von mises stresses are decreasing with increasing of distance between CNT fibers i.e., for the distances 2.4nm, 4nm and 6nm the von mises stresses 269.013MPa, 118.751MPa, and 64.584MPa respectively are obtained. This analysis concluded that deformation of the matrix is decreased with increasing the distance between CNTs in the composite matrix fiber i.e., 0.181×10^{-7} mm, 0.161×10^{-7} mm and 0.875×10^{-6} mm for the distances 2.4nm, 4nm, and 6nm respectively. It is also observed that increase in factor of safety while increasing CNTs distances in the composite matrix. From the von-mises stress 2.4nm then the factor of safety is 1.22, and if the distance is a 4nm and 6nm factor of safeties 2.77 and 5.10 correspondingly. From the above all the outcome, we can conclude that if the distances between CNTs increases in the composite matrix plate then the strength of material also increasing.

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